EXHIBIT 4

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PRINCIPLES OF MICROECONOMICS

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average revenue
total revenue divided by the quantity sold

Column (4) in the table shows **average revenue**, which is total revenue [from column (3)] divided by the amount of output [from column (1)]. Average revenue tells us how much revenue a firm receives for the typical unit sold. In Table 1, you can see that average revenue equals $6, the price of a gallon of milk. This illustrates a general lesson that applies not only to competitive firms but to other firms as well. Average revenue is total revenue ($P \times Q$) divided by the quantity (Q). *Therefore, for all types of firms, average revenue equals the price of the good.*

marginal revenue
the change in total revenue from an additional unit sold

Column (5) shows **marginal revenue**, which is the change in total revenue from the sale of each additional unit of output. In Table 1, marginal revenue equals $6, the price of a gallon of milk. This result illustrates a lesson that applies only to competitive firms. Total revenue is $P \times Q$, and P is fixed for a competitive firm. Therefore, when Q rises by 1 unit, total revenue rises by P dollars. *For competitive firms, marginal revenue equals the price of the good.*

QuickQuiz *When a competitive firm doubles the amount it sells, what happens to the price of its output and its total revenue?*

14-2 Profit Maximization and the Competitive Firm's Supply Curve

The goal of a firm is to maximize profit, which equals total revenue minus total cost. We have just discussed the competitive firm's revenue, and in the preceding chapter, we discussed the firm's costs. We are now ready to examine how a competitive firm maximizes profit and how that decision determines its supply curve.

14-2a A Simple Example of Profit Maximization

Let's begin our analysis of the firm's supply decision with the example in Table 2. Column (1) in the table shows the number of gallons of milk the Vaca Family Dairy Farm produces. Column (2) shows the farm's total revenue, which is $6 times the number of gallons. Column (3) shows the farm's total cost. Total cost includes fixed costs, which are $3 in this example, and variable costs, which depend on the quantity produced.

Column (4) shows the farm's profit, which is computed by subtracting total cost from total revenue. If the farm produces nothing, it has a loss of $3 (its fixed cost). If it produces 1 gallon, it has a profit of $1. If it produces 2 gallons, it has a profit of $4 and so on. Because the Vaca family's goal is to maximize profit, it chooses to produce the quantity of milk that makes profit as large as possible. In this example, profit is maximized when the farm produces either 4 or 5 gallons of milk, for a profit of $7.

There is another way to look at Vaca Farm's decision: The Vacas can find the profit-maximizing quantity by comparing the marginal revenue and marginal cost from each unit produced. Columns (5) and (6) in Table 2 compute marginal revenue and marginal cost from the changes in total revenue and total cost, and column (7) shows the change in profit for each additional gallon produced. The first gallon of milk the farm produces has a marginal revenue of $6 and a marginal cost of $2; hence, producing that gallon increases profit by $4 (from −$3 to $1). The second gallon produced has a marginal revenue of $6 and a marginal cost of $3, so that gallon increases profit by $3 (from $1 to $4). As long as marginal

TABLE 2

Profit Maximization: A Numerical Example

(1) Quantity (*Q*)	(2) Total Revenue (*TR*)	(3) Total Cost (*TC*)	(4) Profit (*TR* − *TC*)	(5) Marginal Revenue (*MR* = *ΔTR* / *ΔQ*)	(6) Marginal Cost (*MC* = *ΔTR* / *ΔQ*)	(7) Change in Profit (*MR* − *MC*)
0 gallons	$ 0	$ 3	−$3			
				$6	$2	$4
1	6	5	1			
				6	3	3
2	12	8	4			
				6	4	2
3	18	12	6			
				6	5	1
4	24	17	7			
				6	6	0
5	30	23	7			
				6	7	−1
6	36	30	6			
				6	8	−2
7	42	38	4			
				6	9	−3
8	48	47	1			

revenue exceeds marginal cost, increasing the quantity produced raises profit. Once the Vaca Farm has reached 5 gallons of milk, however, the situation changes. The sixth gallon would have a marginal revenue of $6 and a marginal cost of $7, so producing it would reduce profit by $1 (from $7 to $6). As a result, the Vacas would not produce beyond 5 gallons.

One of the *Ten Principles of Economics* in Chapter 1 is that rational people think at the margin. We now see how the Vaca Family Dairy Farm can apply this principle. If marginal revenue is greater than marginal cost—as it is at 1, 2, and 3 gallons—the Vacas should increase the production of milk because it will put more money in their pockets (marginal revenue) than it takes out (marginal cost). If marginal revenue is less than marginal cost—as it is at 6, 7, and 8 gallons—the Vacas should decrease production. If the Vacas think at the margin and make incremental adjustments to the level of production, they end up producing the profit-maximizing quantity.

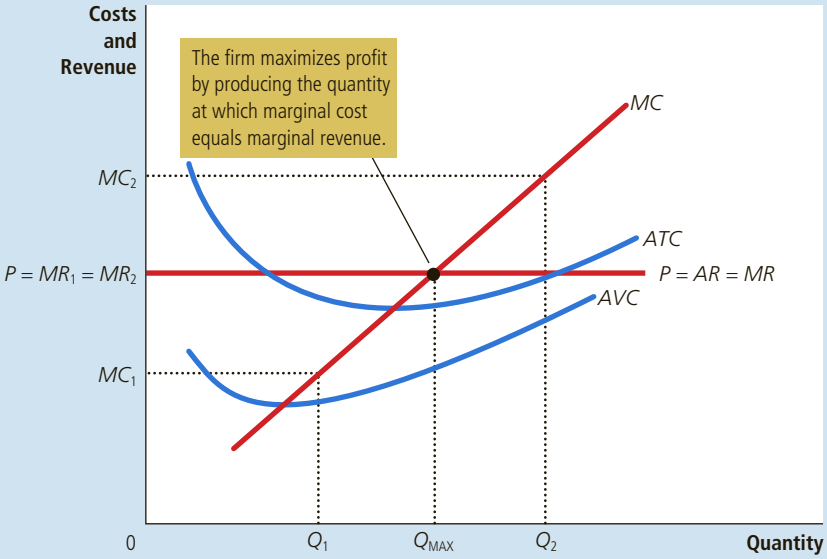
14-2b The Marginal-Cost Curve and the Firm's Supply Decision

To extend this analysis of profit maximization, consider the cost curves in Figure 1. These cost curves have the three features that, as we discussed in the previous chapter, are thought to describe most firms: The marginal-cost curve (*MC*) is upward-sloping. The average-total-cost curve (*ATC*) is U-shaped. And the marginal-cost curve crosses the average-total-cost curve at the minimum of average total cost. The figure also shows a horizontal line at the market price (*P*). The price line is horizontal because a competitive firm is a price taker: The price

FIGURE 1

Profit Maximization for a Competitive Firm

This figure shows the marginal-cost curve (*MC*), the average-total-cost curve (*ATC*), and the average-variable-cost curve (*AVC*). It also shows the market price (*P*), which for a competitive firm equals both marginal revenue (*MR*) and average revenue (*AR*). At the quantity Q_1, marginal revenue MR_1 exceeds marginal cost MC_1, so raising production increases profit. At the quantity Q_2, marginal cost MC_2 is above marginal revenue MR_2, so reducing production increases profit. The profit-maximizing quantity Q_{MAX} is found where the horizontal line representing the price intersects the marginal-cost curve.



of the firm's output is the same regardless of the quantity that the firm decides to produce. Keep in mind that, for a competitive firm, the price equals both the firm's average revenue (*AR*) and its marginal revenue (*MR*).

We can use Figure 1 to find the quantity of output that maximizes profit. Imagine that the firm is producing at Q_1. At this level of output, the marginal-revenue curve is above the marginal-cost curve, showing that marginal revenue is greater than marginal cost. This means that if the firm were to raise production by 1 unit, the additional revenue (MR_1) would exceed the additional cost (MC_1). Profit, which equals total revenue minus total cost, would increase. Hence, if marginal revenue is greater than marginal cost, as it is at Q_1, the firm can increase profit by increasing production.

A similar argument applies when output is at Q_2. In this case, the marginal-cost curve is above the marginal-revenue curve, showing that marginal cost is greater than marginal revenue. If the firm were to reduce production by 1 unit, the costs saved (MC_2) would exceed the revenue lost (MR_2). Therefore, if marginal revenue is less than marginal cost, as it is at Q_2, the firm can increase profit by reducing production.

Where do these marginal adjustments to production end? Regardless of whether the firm begins with production at a low level (such as Q_1) or at a high level (such as Q_2), the firm will eventually adjust production until the

quantity produced reaches Q_{MAX}. This analysis yields three general rules for profit maximization:

- If marginal revenue is greater than marginal cost, the firm should increase its output.
- If marginal cost is greater than marginal revenue, the firm should decrease its output.
- At the profit-maximizing level of output, marginal revenue and marginal cost are exactly equal.

These rules are the key to rational decision making by any profit-maximizing firm. They apply not only to competitive firms but, as we will see in the next chapter, to other types of firms as well.

We can now see how the competitive firm decides what quantity of its good to supply to the market. Because a competitive firm is a price taker, its marginal revenue equals the market price. For any given price, the competitive firm's profit-maximizing quantity of output is found by looking at the intersection of the price with the marginal-cost curve. In Figure 1, that quantity of output is Q_{MAX}.

Suppose that the price prevailing in this market rises, perhaps because of an increase in market demand. Figure 2 shows how a competitive firm responds to the price increase. When the price is P_1, the firm produces quantity Q_1, the quantity that equates marginal cost to the price. When the price rises to P_2, the firm finds that marginal revenue is now higher than marginal cost at the previous level of output, so the firm increases production. The new profit-maximizing quantity is Q_2, at which marginal cost equals the new, higher price. *In essence, because the firm's marginal-cost curve determines the quantity of the good the firm is willing to supply at any price, the marginal-cost curve is also the competitive firm's supply curve.* There are, however, some caveats to this conclusion, which we examine next.

14-2c The Firm's Short-Run Decision to Shut Down

So far, we have been analyzing the question of how much a competitive firm will produce. In certain circumstances, however, the firm will decide to shut down and not produce anything at all.

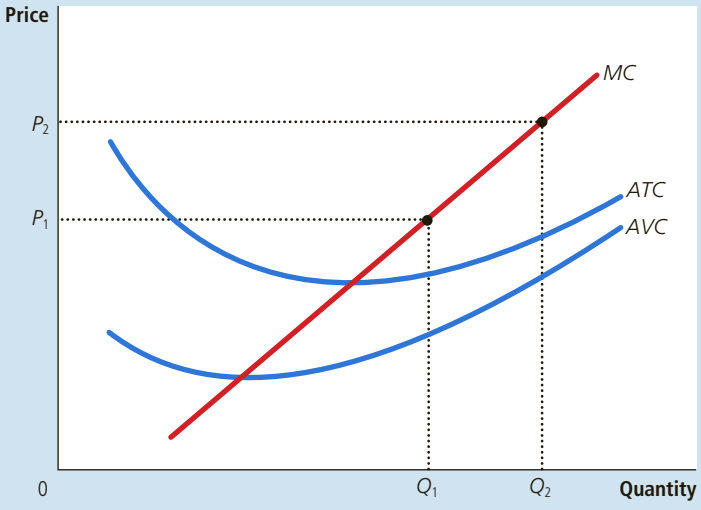


FIGURE 2

Marginal Cost as the Competitive Firm's Supply Curve

An increase in the price from P_1 to P_2 leads to an increase in the firm's profit-maximizing quantity from Q_1 to Q_2. Because the marginal-cost curve shows the quantity supplied by the firm at any given price, it is the firm's supply curve.

3. A competitive firm's short-run supply curve is its _____ cost curve above its _____ cost curve.
   a. average total, marginal
   b. average variable, marginal
   c. marginal, average total
   d. marginal, average variable
4. If a profit-maximizing, competitive firm is producing a quantity at which marginal cost is between average variable cost and average total cost, it will
   a. keep producing in the short run but exit the market in the long run.
   b. shut down in the short run but return to production in the long run.
   c. shut down in the short run and exit the market in the long run.
   d. keep producing both in the short run and in the long run.
5. In the long-run equilibrium of a competitive market with identical firms, what are the relationships among price P, marginal cost MC, and average total cost ATC?
   a. $P > MC$ and $P > ATC$.
   b. $P > MC$ and $P = ATC$.
   c. $P = MC$ and $P > ATC$.
   d. $P = MC$ and $P = ATC$.
6. Pretzel stands in New York City are a perfectly competitive industry in long-run equilibrium. One day, the city starts imposing a $100 per month tax on each stand. How does this policy affect the number of pretzels consumed in the short run and the long run?
   a. down in the short run, no change in the long run
   b. up in the short run, no change in the long run
   c. no change in the short run, down in the long run
   d. no change in the short run, up in the long run

SUMMARY

- Because a competitive firm is a price taker, its revenue is proportional to the amount of output it produces. The price of the good equals both the firm's average revenue and its marginal revenue.
- To maximize profit, a firm chooses a quantity of output such that marginal revenue equals marginal cost. Because marginal revenue for a competitive firm equals the market price, the firm chooses quantity so that price equals marginal cost. Thus, the firm's marginal-cost curve is its supply curve.
- In the short run when a firm cannot recover its fixed costs, the firm will choose to shut down temporarily if the price of the good is less than average variable cost. In the long run when the firm can recover both fixed and variable costs, it will choose to exit if the price is less than average total cost.
- In a market with free entry and exit, profit is driven to zero in the long run. In this long-run equilibrium, all firms produce at the efficient scale, price equals the minimum of average total cost, and the number of firms adjusts to satisfy the quantity demanded at this price.
- Changes in demand have different effects over different time horizons. In the short run, an increase in demand raises prices and leads to profits, and a decrease in demand lowers prices and leads to losses. But if firms can freely enter and exit the market, then in the long run, the number of firms adjusts to drive the market back to the zero-profit equilibrium.

KEY CONCEPTS

competitive market, p. 268
average revenue, p. 270
marginal revenue, p. 270
sunk cost, p. 275

QUESTIONS FOR REVIEW

1. What are the main characteristics of a competitive market?
2. Explain the difference between a firm's revenue and its profit. Which do firms maximize?
3. Draw the cost curves for a typical firm. Explain how a competitive firm chooses the level of output that maximizes profit. At that level of output, show on your graph the firm's total revenue and total cost.
4. Under what conditions will a firm shut down temporarily? Explain.
5. Under what conditions will a firm exit a market? Explain.